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Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

A REVIEW OF THE 'ENVIRONMENT AND SAFETY' CONTRIBUTIONS TO THE 1978/79 ENERGY PROGRAM OUTPUTS OF THE CANMET 'MINING' SUB/SUB/ACTIVITY

by

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February 1979.

ENERGY RESEARCH PROGRAM
MINING RESEARCH LABORATORIES

REPORT ERP/MRL No. 79-85 (TR)

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SUMMARY

This report describes the outputs achieved during 1978/79 by the scientists contributing to the improvement of the underground environment in Canadian coal mines by the reduction of fire and explosion hazards.

The outputs are pertinent to five (5) general areas of interest:

(1) detection and control of methane emission into the coal mine environment,

(2) early detection of heating due to spontaneous combustion underground,

(3) research and development associated with the explosibility of coal dust samples,

(4) research and development to improve equipment and standards for fire resistant and explosion-proof electrical, diesel and other equipment used underground in coal mines and in other industrial locations having similar hazards,

(5) certification of fire resistant and explosion-proof equipment on a cost recovery basis for the coal mining industry and other industries subjected to similar fire and explosion hazards.

This work is carried out in three laboratories of the Mining Research Laboratories of CANMET: The Western Office in Calgary, the Canadian Explosive Atmospheres Laboratory and the Canadian Explosives Research Laboratory both in the Bell's Corners Complex of the Energy, Mines and Resources Department in Ottawa. Nine (9) scientists from these

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laboratories contributed 11 reports (8 completed the editing process, 3 are in process, 3 are for external publication) in the above areas of interest since April 1/78 to the present. A little more than 10 professional and technical man years (approximately equally divided), had been allocated to the work.

Of the 24 formal milestones, 9 have been 100% completed, 4 nearly so, 7 delayed significantly because of circumstances beyond the direct control of the scientists involved, 2 proved to be unnecessary, and 2 were not due until the end of the fiscal year. Two studies were completed which were not assigned formal milestones.

Therefore it is likely that approximately 70 percent of the work has been or will have been achieved before the end of the fiscal year.

Reference to the Table of milestones will be of assistance when comparing the output descriptions to the appropriate milestones.

TABLE 1 - 1978/79 ENERGY PROGRAM MILESTONES

Element No. & Title		Milestone Description	Original Completion Date	Responsible Scientist
3.3.4.1.02.01 Ventilation	1)	Feasibility report on environmental monitoring	Dec. 31, 1978	R. Chakravorty
	2)	Diesel contribution to environment - report	Dec. 31, 1978	D. B. Stewart
3.3.4.1.02.02 Spontaneous Combustion	1)	Report on early detection of spontaneous combustion	Feb. 28, 1979	R. Chakravorty
3.3.4.1.02.03 Methane Control	1)	Report methane emission and control Canmore	Sept. 1978	R. Chakravorty
	2)	Report on methane emission Balmer N. & hydraulic mines	March 1979	R. Chakravorty
	3)	Report stage 1 contract Canmore methane drainage	March 1979	R. Chakravorty
3.3.4.1.02.04 CH_4/dust explosions	1)	Explosion-related characteristics of coal report	Sept. 1978	K. Feng
	2)	Minimum concentration and ignition energy for coal dust explosions	March 1979	K. Feng
3.3.4.1.03.01 Electrical Equipment Safety R/D	1)	Ignition Sensitivity of various explosive gas/air mixtures	Dec. 1978	S. Silver
	2)	Calibration of New Breakflash	Sept. 1978	S. Silver
	3)	Combustible gas detector behaviour	June 1978	G. Lobay

TABLE 1 - 1978/79 ENERGY PROGRAM MILESTONES (continued)

Element No. & Title		Milestone Description	Original Completion Date	Responsible Scientist
3.3.4.1.03.02 Diesel Equipment Safety R/D	1)	S/A reports on flameproof studies	March 31, 1979	P. Mogan
	2)	Dynamic stress in scrubbers	June 30, 1978	P. Mogan D. Dainty
	3)	Diesel code	Dec. 31, 1978	D. Dainty
	4)	1 pass scrubber explosion prevention	Sept. 30, 1978	D. Dainty N. Sarin
3.3.4.1.03.03 Development of New Apparatus	1)	Report re Fire Resistant Fluid facility	March 1979	N. Sarin
	2)	Report re impact ignition by light alloys	Sept. 1978	G. Lobay
	3)	Report re design parameters of Intrinsic Safety Apparatus	March 1979	S. Silver
	4)	Report re gas mixture preparation apparatus	Nov. 1978	S. Silver
3.3.4.1.03.10 General Safety R/D	1)	Static electricity report	March 1978	S. Silver
	2)	Blowout wall Model Study	July 1978	J. Bossert
3.3.4.1.09.03 Cost Recovery	1)	Report on 77/78 Certification	July 1978	J. Bossert
	2)	Report on 77/78 Contract Testing	July 1978	J. Bossert
	3)	Report on 77/78 Contract Research	June 1978	J. Bossert

3.3.4.1.02 UNDERGROUND ENVIRONMENT PROJECT

3.3.4.1.02.01 VENTILATION ELEMENT

Feasibility Report on Environmental Monitoring (milestone 1)

A brief review of the environmental monitoring systems used abroad was made in the paper presented at CIM in April 1978 and the paper entitled "Environmental Monitoring for Safety in Underground Coal Mining" was published subsequently in CIM Bulletin, Jan. 1979. Further review and literature search on the subject was made this year but no prototype system could be identified and procured for demonstration purposes. The system developed by Powers Conspec was examined but in the present form found unsuitable for trial in a coal mine. In late 1978 KRL management also advised us that presently they are not interested in the demonstration trial of an environmental monitoring system for the proposed No. 6 Panel of hydraulic mine. Further work is not contemplated so no report planned for this year. (R. Chakravorty)

Diesel Emissions and Mine Ventilation (milestone 2)

Emissions from diesel engines pose a hazard to health in all underground workings including coal mines.

A paper entitled "Diesel Emissions and Mine Ventilation" was prepared in accordance with milestone 2 and submitted to the CIMM which published it in the Bulletin in the March 1978 issue, in the Environmental Control Section.

The paper was a review of several years of work at CEAL and quoted liberally from the literature. The abstract is given below.

In the past few years, much effort has been spent in elucidating the impact of diesel engines on the mine environment. This paper summarized diesel fundamentals, exhaust emissions and typical tailpipe concentrations. Mine sampling results and an evaluation of exhaust treatment systems are discussed. A review of changes in pollutant concentrations between the tailpipe and the mine exit is made and suggestions are given to reduce operator exposure to diesel contaminants. (D.B. Stewart)

3.3.4.1.02.02 SPONTANEOUS COMBUSTION ELEMENT

Early Detection (milestone 1)

Work for carbon monoxide monitoring system and infra-red techniques for early detection of spontaneous combustion was continued throughout this year and a number of heatings were successfully located using the technique. Based on the extended field trials, a report is now completed discussing the relative merits or demerits of different systems used for early detection of heating in coal mines. It is proposed to present a paper on this study at the 2nd International Mine Congress in November 1979. (R. Chakravorty)

Effect of Moisture - Century Coal (no milestone assigned)

This work was not originally scheduled on the energy program milestone table of 1978/79. The work was however accepted and completed. Pan Canadian Petroleum Limited (PCPL) hopes to supply Century coal to Ontario Hydro in future, but due to the high moisture content and the low heating value of the coal, it cannot compete with the coal from the Eastern United States. PCPL wants to decrease transportation costs and increase the heating value of the coal by reducing the moisture content from 18% to 12%. PCPL has requested the Mining Research Laboratories to study the coal and find the minimum moisture content at which the coal is not liable to spontaneous heating during transportation by rail and storage in piles. The effect of moisture on the spontaneous heating characteristics of Century coal has been studied. Results indicate that reducing the moisture content of Century coal from 18% to 12% does not increase the liability of spontaneous heating. The results are reported in Report ERP/MRL 78-12 (CF) entitled "Study on the Effect of Moisture on the Spontaneous Heating of Century Coals." (K. Feng)

3.3.4.1.02.03 METHANE CONTROL ELEMENT

Methane Emission and Control - Canmore (milestone 1)

Studies on the methane emission pattern at the Riverside Mine, Canmore, is being continued and a field laboratory using a trailer is now established near the mine site. Delay in obtaining the trailer and associated equipment delayed the work to some extent. The results so far indicate that large emission of methane could be frequently experienced during drainages through faults or disturbed areas. A few incidences of high methane emission were observed after blasting operation. More results will be needed to complete the study. Preliminary report is now under preparation and will be completed by the end of March 1979. (R. Chakravorty)

Methane Emission - McIntyre (milestone 2)

Difficulty in the procurement of methane monitoring system certified for underground use is delaying this work. Initial studies also indicates that the methane emission problem is not significant at this stage in Hydraulic Mine & B.N. Mine. No report is planned for this fiscal year. (R. Chakravorty)

Methane Drainage Contract - Canmore Stage 1 (milestone 3)

The contract has not been issued as yet. Contractor's report is not expected until end of 1979. CANMET report will be prepared after reviewing contractor's report. Expected date February/March 1980.

3.3.4.1.02.04 METHANE/COAL DUST EXPLOSION ELEMENT

Explosion-Related Characteristics of Coal (Milestone 1)

This work has been completed. The release of methane from 4 Canadian sub-bituminous coal samples (2 Eastern and 2 Western mountain) has been measured. The results indicate that Cape Breton coals desorb gas more slowly than mountain coals and less methane is released initially. However, more gas is released from Cape Breton coal over a longer period of time and the concentration of ethane and propane is higher than in the mountain coal samples. The dust samples from Cape Breton contained a high volatile matter component and were characterized by a smaller particle size as received.

Because the receipt of coal dust samples from the McIntyre Coal Company has been delayed, the comprehensive report of milestone 1 has consequently been delayed. (K. Feng)

Minimum Concentration and Minimum Ignition Energy (milestone 2)

This milestone has been re-scheduled to the 1979/80 FY for the following reasons:

(a) the technician assigned to this work was hired in late August 1978 thus delaying the work 5 months, and

(b) some effort planned for this was transferred to element 3.3.4.1.02.02 Spontaneous Combustion on request of Century Coal and,

(c) the reproducibility of the minimum concentration determined in the Hartman apparatus is poor. Modifications are underway. (K. Feng)

3.3.4.1.03 EQUIPMENT R/D PROJECT

3.3.4.1.03.01 ELECTRICAL EQUIPMENT SAFETY R/D ELEMENT

Ignition Sensitivity and Calibration of New Apparatus (milestones 1 & 2)

To determine with greater precision and repeatability the relative incendivity and safety factors associated with the use of various gas/air mixtures employed in testing the safety of protective devices for underground coal mines (such as flame arresters, intrinsically safe equipment etc.), an improved break-flash design and calibration method are required i.e., better than that of the present Standard IEC Test Apparatus.

Work undertaken during 78/79 in connection with these milestones has had three facets:

(1) Four unique types of break-spark electrodes have been studied to determine operational criteria, incendivity, sensitivity and stability. This work is described in report ERP/MRL 79/3 (TR) entitled "Operational Criteria for Break-Flash Apparatuses Used in Intrinsic Safety Testing". This is a report of some significance.

(2) A report is in progress describing break-spark phenomena. Six sets of unique electrodes were studied. The results indicated that for improved sensitivity, incendivity and repeatability, hardened electrode materials should be employed to minimize wear, and that a combination of a spring loaded steel wire electrode and a stationary tungsten wire electrode should be employed in such a way as to produce a multiple make-break type of contact.

(3) Calibration of a new "stuttering contact" break-flash (completed except for electronic counter) has had to be postponed from September 1978 to December 1979 because of demands of certification on the effort of the electronics technician. (S. Silver)

3.3.4.1.03.01 ELECTRICAL EQUIPMENT SAFETY R/D ELEMENT (continued)
Combustible Gas Detectors Behaviour (milestone 3)

This work was undertaken to provide input to the standards committees concerned for the formulation of performance standards for gas detection equipment. The data obtained during the investigations has been presented to Instrument Society of America Subcommittee SP12.13 and Canadian Standards Association Subcommittee C22.2 No. 152. The latter subcommittee has already issued a revision sheet for the existing standard based on these investigations. Reports written in fulfillment of this milestone were:

ERP/MRL 78-60 (TR) "Combustible Gas Detection Instrument Performance in Stagnant Atmospheres"

ERP/MRL 78-35 (TR) "Laboratory Experience with Combustible Gas Detection Equipment Tested to CSA Standard C22.2 No. 152 - 1976"

The first report indicates that combustible gas detection instruments calibrated under flowing gas conditions (a normal practice), may exhibit significant readout errors when exposed to the same gas concentration under stagnant atmospheric conditions. Four of five instruments evaluated for this effect displayed errors as great as 25% of the lower explosive limit (LEL), depending upon sensor orientation, gas or vapour used, and installed accessories. Potential hazards and application solutions are discussed.

The second report presents some background information about CSA Standard C22.2 No. 152-1976 and outlines some of the problems which have been encountered by the testing authority during its initial implementation. Several suggestions have been made as to how the Standard could be modified to help eliminate these problems. (George Lobay)

3.3.4.1.03.02 DIESEL EQUIPMENT SAFETY R/D ELEMENT (continued)

S/A Reports on Flameproof Studies (milestone 1)

Ignition of methane in underground coal mines can be brought about by frictional and impact heating. Brakes, starters, and clutches on mobile diesel equipment are sources of such heating with presently undefined risks. The contractor is comparing energy levels found in normal and abnormal operations of these components with levels known to produce methane ignition, as described in the SA's report entitled "Frictional Hazard Criteria for Mobile Diesel Powered Mining Equipment" ERP/MRL 78-38 (TR). This work will then be used to define equipment requirements in the Canadian Flameproof Diesel Standard.

Current flameproof diesel exhaust systems use spaced plate flametraps downstream from wet scrubbers. Tar condenses on the plates, so extensive daily maintenance is required. Recent British research has established that flametraps remain effective at higher temperatures. A study carried out under a research agreement at the University of British Columbia has developed a design to exploit this principle which should result in a flameproof system which does not require daily maintenance, and therefore has less risk of damage and improper assembly.

Reports for both studies are due on March 31, 1979.
(P. Mogan)

3.3.4.1.03.02 DIESEL EQUIPMENT SAFETY R/D ELEMENT (continued)
Dynamic Stress in Scrubbers (milestone 2)

The safe design of diesel exhaust water scrubbers, which must withstand explosions when approved for use in coal mines, is a complex matter which cannot be predicted by first principles. Consequently, several R/D investigations have been carried on in conjunction with the explosion testing of commercial scrubbers and by varying several parameters of a laboratory constructed model in order to determine the design principles involved.

Test results have thus far shown in general that the highest and most hazardous explosion pressures are those resulting from unfavourable interaction between the collective volumes upstream of the gas dispersion point into the scrubber water, and the volume of the mist de-entrainment chamber immediately prior to the exhaust flame arrester. However, a definitive correlation of maximum explosion pressure data with the volume ratios for the prototype and the mock-up scrubbers was not forthcoming. Therefore, on the basis of tests done thus far, minimum pressure design requires a modest series of prototype explosion tests.

Other parameters, such as slot widths, internal baffling, and suitably selected exhaust flametrap free area, appear to have a minor influence on the generation of high pressures.

Maximum explosion pressure reduction can result from the prevention of 'pressure piling' effects in both series and parallel scrubber chamber configurations, if small 'ignition transmission' holes are placed such that gas flow is not substantially affected and subsequent or adjacent chambers communicate with the chamber in which primary ignition occurs allowing simultaneous deflagration.

Other research tests carried out in connection with a certification investigation (Rhino vehicle update) showed that the addition of one 90° bend to a water scrubber intake system (composed of 3 straight pipe lengths, 1-180° bend and 1-90° bend), was critical in terms of preventing transmission of explosions through the intake system into the empty flame trap-equipped scrubber. This is a significant and unexpected result.

A manuscript describing this work was prepared some time ago in fulfillment of milestone 2, and an abstract has already been submitted to the Organizing Committee of the XVIII International Safety in Mines Research Conference, October 1979, in Yugoslavia, for publication of the results.
(P. Mogan, N. Sarin)

3.3.4.1.03.02 DIESEL EQUIPMENT SAFETY R/D ELEMENT (continued)

Canadian National Flameproof Diesel Code (milestone 3)

In order to standardize the underground diesel regulations so that federal certification of dieselized equipment would be acceptable to all Canadian Provincial jurisdictions, to foreign and domestic machinery manufacturers, and to mine operators, CEAL has been attempting to respond to the unanimous request of the provincial inspectorates to produce a draft code by December 31, 1978.

This task has been 90% completed. The uncompleted portion relates to formalizing a criterion for prescribing ventilation to reduce diesel exhaust emissions to acceptable levels. This in turn has had to await the delayed completion of the contracted study entitled "Health Implications of Exposure of Underground Workers to Diesel Exhaust Emissions" (Ian W. French & Associates).

The final contract report was received at CEAL at the end of December 1978. It is expected that the requested draft will be completed by CEAL and forwarded to the provincial inspectorates by March 31, 1979. (D. Dainty, P. Mogan and N. Sarin)

One-Pass Scrubber Explosion Prevention (milestone 4)

To determine if a margin of explosion safety is provided by a water seal in a diesel exhaust scrubber in addition to the use of mandatory flame arresters, explosion tests on a mock-up system were undertaken. The results showed for example, that verticle baffles sealed by as little as 12mm of water prevented transmission of all 10 explosions of 9.75% methane in air mixtures. The results are fully reported in Report ERP/MRL 78-68 (TR) entitled "Flameproofness of Water-Seal in Diesel Exhaust Scrubbers for mines" June 1978, thus completing the milestone.

This work provides background data to improve judgements with respect to the safety certification of flameproof equipment for underground coal mines. (D. Dainty and N. Sarin)

3.3.4.1.03.03 DEVELOPMENT OF NEW APPARATUS ELEMENT

Development of Fire Resistant Fluids Facility (milestone 1)

Because hydraulic fluids are used extensively underground on both electrical and diesel machinery, and because they represent a serious source toxicity, fire and explosion hazard, the provincial inspectorates unanimously agreed that it is essential to certify such fluids for underground use.

This safety approval aspect is properly an integral part of the electrical and diesel machinery certification service already provided by CEAL and is being incorporated into it.

The construction of the test facility is expected to be completed by an external contractor through D.P.W. and the Property Development Section of EM&R by Mar. 31st, 1979. The contract for the construction has already been awarded but no work has begun on the site as of February 17, 1979.

Some of the associated instrumentation and test equipment has already been received and checked for performance. Construction and installation of the instruments in the remote control panel shall be undertaken by CEAL staff when construction of the test chamber has been completed. (N. Sarin)

Impact Ignition by Light Alloys (milestone 2)

Impacts of materials on one another can occur with sufficient energy to cause incendive sparks which can ignite gas-air mixtures present in coal mines and other environments.

Testing of such materials and particularly coatings which are designed to prevent incendive sparks is therefore a matter of importance which other national jurisdictions have already undertaken.

A literature survey on this subject has been completed. The design of the apparatus has been delayed because of the heavy certification load. Construction and commissioning of the apparatus is expected to be completed in 79/80. (G. Lobay)

3.3.4.1.03.03 DEVELOPMENT OF NEW APPARATUS ELEMENT (continued)

Development of a New Intrinsic Safety Apparatus (milestone 3)

The testing of circuits to determine the incendivity of sparks generated by faults in such circuits, has long been a subject of R/D by the coal mining safety authorities. The major drawback to all these devices is that the sparking electrodes deteriorate as they spark thus changing their sensitivity to ignition and affecting the repeatability of results.

A new device with special electrodes has been fabricated by TSD save for an electronic counter to be installed by CEAL at a later date (see milestone 2 of 3.3.4.1.03.01) when the certification load frees the necessary technical assistance. This milestone is essentially achieved. (S. Silver)

Automated Precise Gas Mixture Preparation Apparatus (milestone 4)

Fundamental to explosion certification and safety R/D is the routine precise preparation of mixtures of various gases with air. CEAL developed a unique device for this purpose and found that it became useful for several purposes including analyzer calibration, sample preparation for performance checks of gas detection equipment and for intrinsic safety investigations and safety R/D.

Demand on the part of several laboratory scientists for the use of the first apparatus suggested that a second one be built, incorporating additional features such as automation.

This new apparatus has been virtually completed, in partial fulfillment of this milestone. It incorporates a motor to assist the operator to alter the volume of the cylinder by electrical power, and various electronic measuring components to prepare gas-air mixtures with a maximum cumulative error of ± 0.002% for a 20.500% mixture.

The remaining work awaits some outstanding material acquisitions. The milestone has therefore been delayed from November 1978 to May 1979. (S. Silver)

3.3.4.1.03.10 GENERAL SAFETY R/D ELEMENT

Static Electricity Review (milestone 1)

Ignition of dusts and gases by static discharge is a constant safety concern. Consequently, CEAL undertakes R/D and performs tests on materials to check their ability to acquire static charges particularly with respect to coal mining applications.

A report reviewing this subject has been prepared ERP/MRL 78-13 (TR) entitled "Static Electricity in Mines - Update on Safe Products". This report describes how and when electrical charges are most likely to occur in mines and lists some of the usual counter-measures to be taken to reduce this danger. The conditions and bases upon which 'specific resistivities' for various products are prescribed by various national authorities, are compared.

Information from six countries is provided on anti-static 'directives and product specifications' for mines and references are included for guidance. The report concludes that mine safety would be well-served by the formulation of international test standards and directives.

This milestone is completed. (S. Silver)

Comparative Hazard of Explosion-Proof and Intrinsically Safe Equipment

For many years there existed some controvery over the comparative safety of these two types of protective measures for electrical equipment and whether the established safety factors need to be altered. A report entitled "Another Look at the Comparative Safety of Explosion Proof and Intrinsically Safe Electrical Equipment" has been written. This study evaluates the mathematical probability models for each type of safety system according to the different external hazards that may exist in practice. The report concludes that in the practical situation, the two systems are in fact, comparable. This report is in the editing process and no formal milestone for it was established. (S. Silver)

3.3.4.1.03.10 GENERAL SAFETY R/D ELEMENT (continued)
Blowout Wall Model Study (milestone 2)

To try and determine the best way to reduce the damage to the blowout walls in Building No. 9 when the large test pit is exploded, a ½ inch to the foot scale model of the rear section of the laboratory was built complete with a scale model of the test pit. Cardboard cards were used to simulate the blowout panels and the test gas mixture was adjusted until nearly all of the cards were dislodged with each explosion. Then, various proposed modifications to the exhaust tunnels were simulated until the effect of the explosion on the cards was minimized. By this means it was established that tunnel extensions of approximately 40 ft. with an earth mound between the outlet and the blowout wall would offer good protection at a reasonable cost.

The modification has since been made on the actual building and when tested with a maximum force blast (similar to that which completely destroyed our original wall) only one of the temporary plywood panels was dislodged.

This project is complete except for the report.
(J. Bossert)

3.3.4.1.09 COST RECOVERY PROJECT

3.3.4.1.09.03 COST RECOVERY (INDUSTRY) ELEMENT

Summary of Certification for 1977/78 (milestone 1)

A report, ERP/MRL 78-78, entitled "Annual Report on Certification of Equipment for Use in Coal Mines" for the period from July 1, 1977 to June 30, 1978 was written in fulfillment of this milestone. During this period 35 certificates were issued to manufacturers of equipment and material for use in underground mines and two (2) letters of certification were issued for scientific instruments used by our department for underground coal mine research. This represents an increase of 30% over the previous year, mainly in the electrical field. (J. Bossert)

Summary of Contract Testing for 1977/78 (milestone 2)

A report, ERP/MRL 78-77, entitled "Report on Contract Testing Performed by the Canadian Explosive Atmospheres Laboratory for Outside Agencies (July 1/77 to June 30/78)," was written in fulfillment of this milestone. During this period 28 series of explosion tests (representing an average of about 10 tests each) were performed for the Canadian Standards Association using various explosive gas/air mixtures. This represents an increase of about 43% over the previous year. A new method of testing, initiated by the International Electrotechnical Commission and adopted by CSA and ourselves, enabled us to perform these additional tests without seriously overloading our laboratory staff and facilities. (J. Bossert)

Report on Contract Research (milestone 3)

As there were no requests for contract research to be done in CEAL's facilities, no work in this field was performed between July 1, 1977 and June 30, 1978. (J. Bossert)